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REGULATION BY REASON: SCIENCE AND MANAGEMENT IN THE FLOWER GARDENS SANCTUARY, NW GULF OF MEXICO

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ABSTRACT

Because of high levels of hydrocarbon exploration and development in the NW Gulf of Mexico, the management of the Flower Gardens Banks National Marine Sanctuary interacts regularly with the oil industry. Potential threats to the pristine coral reefs of the Sanctuary are posed by seismic exploration, platform and pipeline construction, drilling discharges, discharges throughout the production life of a platform, spills, and spill countermeasures. Protective regulations were developed in response to previous research and affect the proximity of industrial activities to the reefs, platform discharges, and spill response options. Agreements with other Federal agencies, also based on the best available information, affect review of development plans, seismic operations, platform removal, and spill notification and cleanup procedures. The Sanctuary depends heavily on interactions with other resource protection agencies, as well as the scientific community and industry, which provide important technical and logistical support. A monitoring program provides annual data on coral growth rates, population levels, cover, and other parameters. On-going research addresses management concerns and information needs, and includes studies on reef fish community dynamics, coral diseases, and reef restoration techniques. Research and monitoring results are used in making management decisions and to evaluate the effectiveness of existing regulations.

INTRODUCTION

The Gulf of Mexico is a remarkably important body of water, being both highly productive and highly exploited. It yields 40% of U.S. commercial fisheries landings, carries nearly half of all U.S. import/export tonnage, contains four of the country's ten busiest ports and six of the top ten ports handling crude oil, and produces more than 72% of the oil and 97% of the natural gas produced in offshore U.S. waters (Weber et al. 1992). In addition, over 3,600 oil and gas platforms, and over 35,000 km of pipeline exist in the northwest Gulf of Mexico. It is by far the most active area in the world for offshore hydrocarbon development.

Several river systems drain nearly two thirds of the area of the United States into the Gulf of Mexico. Increasingly polluted runoff, combined with high levels of coastal industrial activity and development have significantly altered nearshore ecosystems over the last five decades (Weber et al. 1992).

Offshore development, which began in the 1930's, reached the edge of the continental shelf in the 1970's and has since gone beyond, with production today in over 1000 m of water. Though nearshore environmental quality has been affected by industrial activity in and around the Gulf, development offshore has apparently not significantly affected surrounding environments. Monitoring studies conducted around oil platforms in place for over 10 years (Kennicutt 1995) showed that under normal operating conditions, benthic communities have not been significantly altered and contaminants have not accumulated.

On the outer continental shelf in the Gulf of Mexico are the northernmost living coral reefs in North America (Rezak et al. 1990). Located on the summits of the East and West Flower Garden Banks (roughly 27.9°N, 93.5°W; Fig. 1) these isolated reefs are 195 km south of the Texas/Louisiana border. The banks were discovered by snapper fishermen in the 1880s, and were first mapped in 1937 by the U.S. Coast and Geodetic Survey (Survey Number 6292). Diving surveys confirmed the presence of coral reefs in 1960. Frequent scientific expeditions began in 1970 and have continued. Submarine surveys in the 1970s found extensive tropical communities on deeper zones of the banks, as well as a unique brine seep on the edge of one bank (Rezak et al. 1985).

In 1992, the National Oceanic and Atmospheric Administration (NOAA) designated the banks a National Marine Sanctuary (NOAA 1991), in part to protect the fragile ecosystem from threats posed by increasing levels of anchoring by large and small vessels, increasing levels of offshore development, and destructive fishing techniques. In cooperation with appropriate partners, the Sanctuary staff directs resource protection, education, research, and enforcement efforts. This paper illustrates how resource protection measures at the Flower Gardens have made effective use of scientific information in the development of regulations and policies.

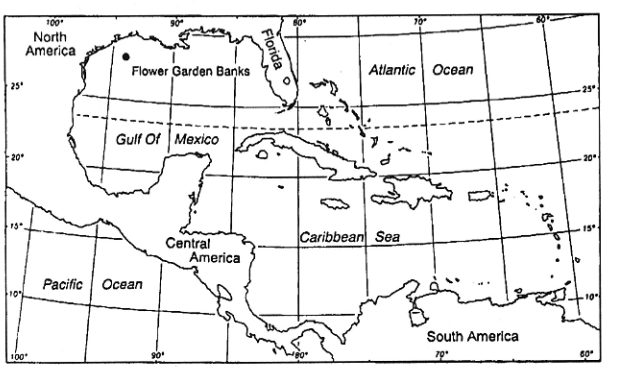

Fig. 1: Location of the Flower Garden Banks in the northwestern Gulf of Mexico.

REGULATORY ZONES

Research in the early 1970s identified the sensitive nature of the tropical fauna on the Flower Garden Banks (e.g. Bright and Pequegnat 1974). In 1974, and in consultation with regional scientists, industry, and others, the U.S. Dept. of Interior's Bureau of Land Management (a portion of which later became the Minerals Management Service [MMS]), which regulates offshore oil and gas activities, designated regulatory zones on and around the banks to control potentially damaging industrial activity. "No-Activity Zones" (Fig. 2) encompassed individual banks and prohibited drilling, discharging, platform or pipeline placement, and other activities that might disturb benthic resources.

"One-Mile Zones" around the banks required shunting of drilling "muds" (fluids used to lubricate the drill string, maintain pressure, and facilitate removal of cuttings) and cuttings through downpipes to appropriate distances, but not more than 10 m, from the seabed. According to research on physical oceanography around the banks (Bright and Rezak 1978), this would eliminate the threat of smothering of corals by sediment plumes or exposure to toxic fractions of drill muds within the shallow portions of the banks. Operators in these zones were also required to establish monitoring programs on the banks that would track the condition of benthic resources.

"Four-Mile Zones" around the Flower Garden Banks (and "Three-Mile Zones" around other banks in the region) required shunting of drilling fluids and cuttings to the bottom, but not monitoring.

Because of the apparent effectiveness of these zones, the regulations adopted by the Flower Gardens Sanctuary in 1992 did not alter MMS stipulations. In 1988, MMS dropped the requirement for industry monitoring of reef resources and began funding a long-term monitoring program at the Flower Gardens. Therefore the One-Mile Zone stipulation was dropped, but the No-Activity Zones and Four-Mile Zones are still in place (Fig. 2).

MONITORING PROGRAM

Some techniques used in the long-term monitoring program today were developed for use at the Flower Gardens for MMS-stipulated industry monitoring during the 1970s. In fact, baseline quantitative data were collected as early as 1974 and comprehensive monitoring began in 1988. Parameters measured include accretionary and lateral coral growth rates, population levels, percent cover, diversity, and evenness (Gittings et al. 1992). Methods and sample sizes used to quantify these parameters have been modified over the years, when appropriate, to streamline the program (e.g. Hagman 1992).

Prior to 1988, industry operators were required to fund a pre-drilling survey, quarterly during-drilling surveys, and three quarterly post-drilling surveys. Sampling included surficial sediment, sediment traps, bivalve tissue assays, hydrographic samples, current meters, and the reef sampling listed above (Continental Shelf Associates, Inc 1985). Between 1988 and 1992, sampling was reduced to twice per year. It was reasoned that since prior studies had shown no impacts of drilling near the reefs, and since no active drilling was occurring near the banks at the time, sampling frequency could be reduced. Also, studies other than those on reef coral growth rates, populations, and other coral community parameters were dropped, with the exception of discrete samples of temperature, salinity, and oxygen levels.

Since 1992, the sampling interval for the monitoring program, now funded jointly by MMS and NOAA, has been annual, owing to the lack of evidence of significant seasonal variation. Other changes have included the addition of *in situ* thermographs and light sensors measuring every two hours, and collection and archival of reef sediment samples. Also, the contractors (Continental Shelf Associates, Inc. and Texas A&M University) have been required to assist in planning and testing new methods for water quality monitoring. A method is currently being tested to quantify dissolved or bioavailable organic contaminants in the Sanctuary.

Monitoring data collected since the late 1970s have shown no significant changes in environmental quality that could be attributed to industrial activity in the region (Gittings et al. 1993). For this reason, neither NOAA nor MMS have substantially changed stipulations imposed by MMS in the mid-1970s.

ANCHORING

Anchoring by large vessels has long been a problem at the Flower Gardens. The banks offer convenient, shallow anchoring locations for ships waiting for orders, making engine repairs, etc. Depths surrounding the banks are over 100 m. Ship captains prefer anchoring shallower, many at the 20 m depths of the banks' crests. Considerable anchor damage has been observed over the past 20 years.

Attempts during the 1970s to minimize incidents included letters by industry representatives to operators suggesting a voluntary ban on anchoring, and MMS provisions pro-

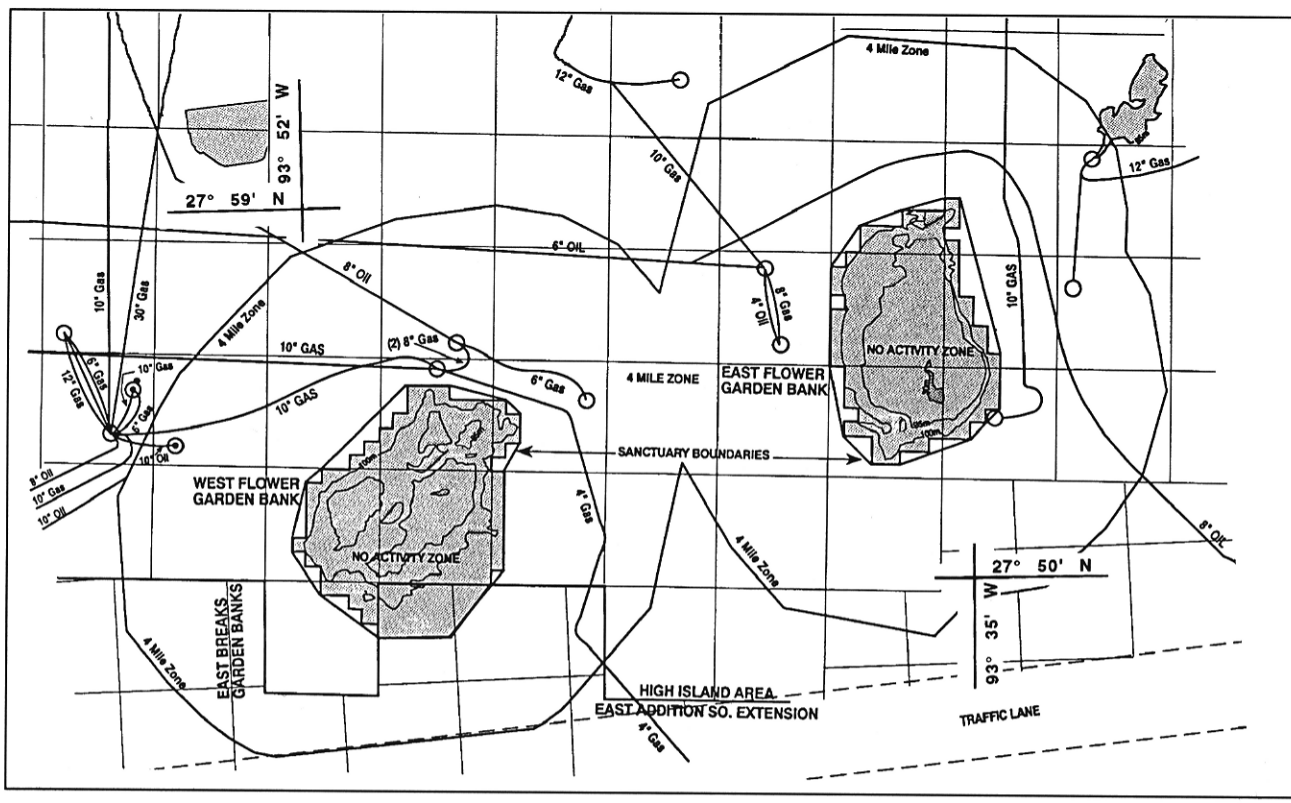

Fig. 2: Location of the Flower Garden Banks relative to pipelines (labeled "oil" or "gas"), platforms (open circles), regulatory boundaries (labeled by "zone"), outer continental shelf lease blocks (rectangles), and shipping traffic lane. For scale, the square lease blocks are 4.8 km by 4.8 km.

hibiting anchoring by industry vessels in the No-Activity Zones. But this did not deter many vessels outside the oil industry from anchoring, particularly foreign-flagged vessels. An attempt in 1982, through the Fishery Management Plan for Corals and Coral Reefs would have prohibited anchoring at the Flower Gardens, but the implementing regulations did not contain this prohibition.

An anchoring incident in 1983 allowed researchers to quantify the amount of damage caused by one vessel, as well as the potential for recovery. Citing these and other data, NOAA drafted regulations that would prohibit anchoring by vessels greater than 100 feet in the Flower Gardens Sanctuary (which had not yet been designated; see NOAA 1991). They would also require that no more than 15 feet of chain or wire rope be attached to anchors being used on the banks. This would significantly reduce damage caused by chains sweeping across the reefs with changing currents and winds.

In an effort to reduce damage caused by increasing number of dive charters visiting the Flower Gardens in the late 1980s, a group of 24 volunteer divers installed 12 mooring buoys at the Flower Gardens in 1990. In response, NOAA modified the proposed regulations, which became final in 1992, to prohibit anchoring by all vessels in areas where moorings are available.

Currently, NOAA nautical charts are appropriately marked to notify mariners of regulations prohibiting anchoring in the Sanctuary. Significant threats still exist, however, because of the lack of information on foreign charts, which are often used on foreign-flagged vessels. Attempts are currently underway to rectify this problem.

FISHING

Commercial snapper and grouper fishing at the Flower Gardens has taken place since the 1880s. No data have ever been offered suggesting that commercial or recreational exploitation exceeded acceptable limits. Thus, no Sanctuary regulations have been proposed that would specifically limit allowable harvest levels in the Sanctuary.

Regulations do exist, however, that limit fishing techniques destructive to benthic habitats. Trawls, traps, and bottom long-lining, for example, are prohibited. Conventional hook-and-line fishing, including the use of electrically operated reels, is allowed.

SEISMIC EXPLORATION

Most current surveys on the outer continental shelf (OCS) utilize multiple air guns as sound sources. Air guns release compressed air, producing pressure waves as the bubbles implode. State-of-the-art three-dimensional surveys generally use an array of 50 or more air guns, each containing 1639 cubic cm of air compressed to 2,000 psi (1378 pa), which are discharged simultaneously every 10 to 15 seconds. Seismic reflections are recorded by cables that may trail for five kilometers or more behind the receiving ship.

Geophysical surveys and seismic exploration are not prohibited by the regulations of the Flower Gardens Sanctuary, as long as they do not employ high velocity explosives or electrical sound sources. It has been fairly well demonstrated that air guns do not have physiological impacts on marine organisms in the configuration in which they are generally used (Linton et al. 1986). Unlike explosives, historically the preferred sound source for seismic surveys, air guns produce comparatively low peak pressures and have a slow rise time to peak pressure. Explosives are characterized by rapid rise times (high velocity), high peak pressures, and rapid pressure decreases. These characterstics cause swim bladders of fish to rupture before they can compensate for the changing pressure (Linton et al. 1986).

But NOAA has stated that air guns use may be regulated in the future if they are shown to have an adverse impact on sanctuary resources. In such an event, regulations would be proposed and offered for public review and comment.

Seismic vessel operations occasionally interfere with recreational diving, and sometimes cause the accidental destruction of mooring buoys and the loss of expensive seismic survey gear in the Sanctuary. In 1992, the Sanctuary and the MMS cooperated in an effort to determine how best to avoid conflicts between survey operations, boat moorings and recreational divers. MMS issued a Letter to Lessees requiring notification of the Sanctuary prior to conducting surveys if buoys or recreational diving operations may be affected. In such cases, it requires removal of buoys before the survey and reinstallation afterward, as well as announcement of the activity in the Notice to Mariners. The Sanctuary also notifies dive charters regarding the dates of surveys and buoy availability.

PIPELINE OPERATIONS

Prior to the designation of the Sanctuary, a proposal was submitted to MMS that would have led to the installation of an oil pipeline between the East and West Flower Garden Banks. Because previous studies showed prevailing currents from the west, concerns arose about the fate of any oil released from the pipeline on the resources of the East Flower Garden Bank. In response, the operator proposed to reroute the pipeline to the east of the East Bank (adding over two million dollars to the cost of the project).

Fearing leaks, operators generally "shut in" pipelines when pressures in the line drop 15% below the normal low range of operating pressures (this is called a 15% Pressure Safety Low [PSL] setting). Because of the sensitivity of reef resources to oil, MMS, in consultation with NOAA and offshore operators, revised pipeline operating requirements in the Four-Mile Zone around the Flower Gardens. They now require a 10% PSL setting be used in that area. That is, "shut in" is required when a 10% drop in pressure below the normal low range occurs. This has the effect of not only reducing the threat posed by oil spills from pipelines, but also alerting operators to the heightened vigilance required when working around these unique ecosystems.

SPILL NOTIFICATION

Owing to the enormous amount of exploration and production in the northwest Gulf of Mexico, small oil spills from platforms and pipelines are not uncommon in the region. Most spills, however, do not pose a significant threat to the environment, particularly spills in offshore waters, where coastal impacts are unlikely. Furthermore, the Flower Gardens, by virtue of 20 m of water covering the reefs, are protected somewhat from the effects oil floating on the surface. Nevertheless, spills do pose a danger to some Sanctuary resources, particularly those that surface or live near the surface (turtles, cetaceans, mantas, sharks, and some fish).

In 1995, MMS conducted a risk assessment to identify areas around the Flower Gardens from which spills could contact the Sanctuary within specific periods of time (3, 10, and 30 days). Using an Oil Spill Risk Assessment (OSRA) model, which employs long-term regional data on currents, wind stress fields, heat flux, river input, and other factors, contact probabilities were calculated by season for 500 locations in the northwest Gulf. For each season and time interval, and for all seasons combined, contours of conditional probabilities, expressed in percentages, were determined. The contours were then superimposed over OCS lease blocks (Fig. 3 provides an example).

In response to this analysis, NOAA requested that MMS require operators in leases within the 10% or higher, 3-day spill contact probability zone to notify the Sanctuary if

they have a spill for which a countermeasure response occurs. This affects over 420 OCS leases. This request presumes that spills for which there is no response are not likely to threaten Sanctuary resources. It also takes into account the fact that most toxic fractions of spilled oil are significantly reduced after three days. This is not meant to suggest that other effects would not occur, but simply enables timely implementation of monitoring protocols to track the effects of the spill.

SPILL COUNTERMEASURES

Spill response in offshore waters generally involves oil booms, skimmers, sorbents, occasionally dispersants, and in the future, perhaps regular use of bioremediation and *in situ* burning. Prior to 1996, the policy of the Flower Garden Banks National Marine Sanctuary was to discourage the use of dispersants in the Sanctuary or in waters likely to enter the Sanctuary. This was based on limited knowledge of the dynamics of dispersant/oil mixture movement in the water column, and concern over the known effects of oil on corals and other benthic organisms.

A policy change was recommended following review of the scientific literature on dispersants and dispersant use. The review suggested that benthic, pelagic, and surface-dwelling resources would either be unlikely or less likely to be harmed by dispersant application than by a "no action" alternative.

The National Research Council (1989) showed that, at recommended application rates, dispersants do not contribute significantly to lethal or sublethal toxicities of dispersed oils. Therefore, the information below is based on research on the lateral and vertical mixing dynamics of dispersed oil and the effects of dispersed and untreated oil on marine organisms.

Data on vertical mixing of dispersed oil in the water column suggest that it is extremely unlikely that dispersed oil concentrations would have significant effects on benthic resources at the Flower Gardens, which are nearly 20 m deep. Dispersed oil concentrations below 10 m have been shown to be less than 1 ppm, which is significantly lower than would be necessary to affect most adult and larval organisms (Fucik et al. 1994).

With regard to the water column, it has been shown that dispersed oil concentrations below 3 m remain below 10 ppm, which is below measured LC50s for most life stages of common toxicity test organisms (using data from 24-, 48-, and 96-hour toxicity tests; Fucik et al. 1994). Within an hour following application, oil concentrations at all depths, including the surface, have been shown to be below 10 ppm, and within five hours of application, they are below 1 ppm at all depths (Mackay and Wells 1983). So impacts may, for all practical purposes, be limited to the first hour following application for organisms such as near-surface phytoplankton and zooplankton; animals frequently surfacing (for example, turtles, dolphins, and whales); animals swimming very near the surface (occasionally sharks and manta rays); and pelagic eggs and larvae.

For some members of pelagic groups, as well as seabirds, it is likely that an untreated surface slick would be more harmful than dispersed oil. This is because untreated oil increases the likelihood of inhalation of noxious or toxic

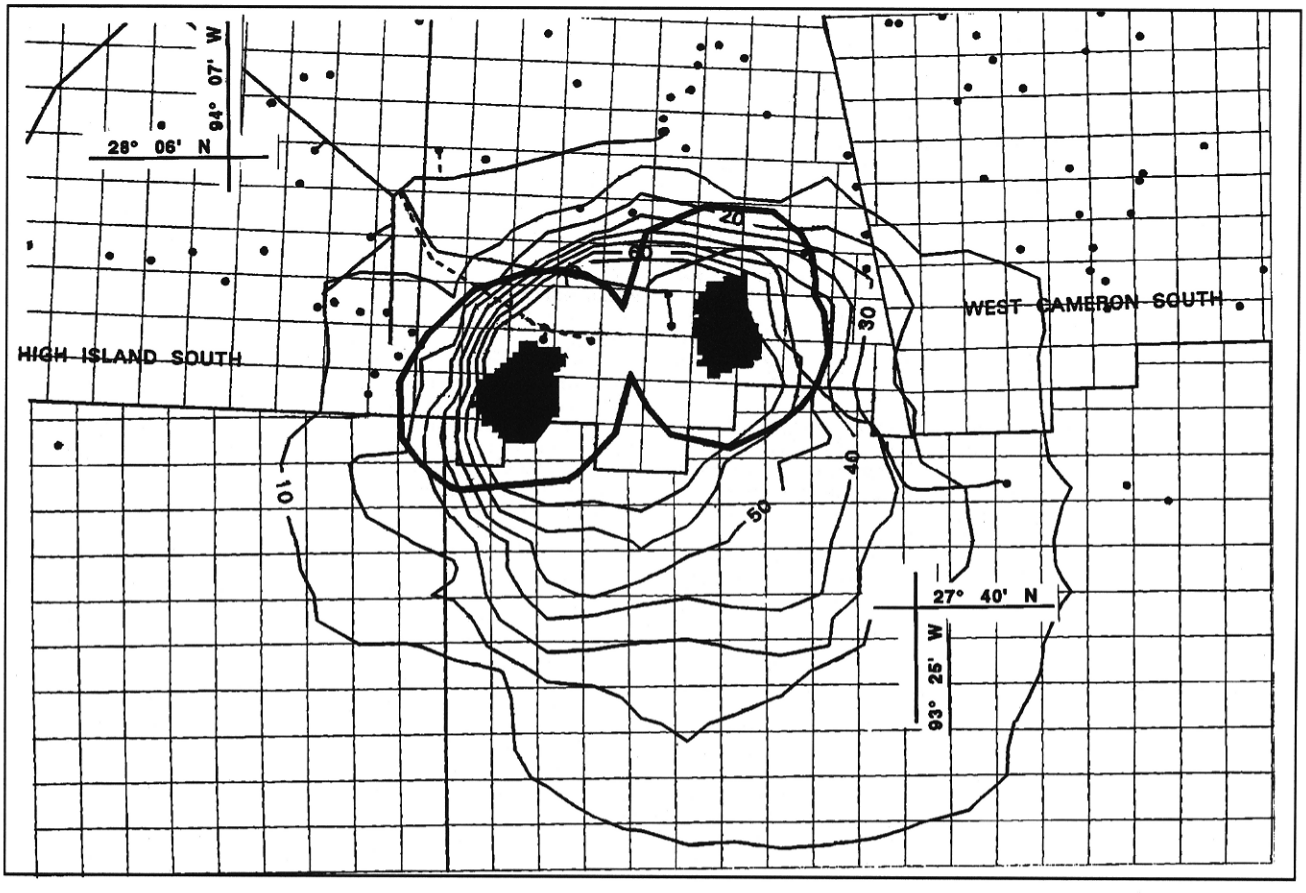

Fig. 3: Three-day spill contact probabilities (contours) for the summer season for lease blocks on the outer continental shelf in the vicinity of the Flower Gardens. Four-Mile Zones (thick line), No-Activity Zones (dark areas), lease blocks (squares, each 0.23 km^2), existing platforms (dots), and oil pipelines (jagged lines mostly in northwest quadrant) are also indicated.

hydrocarbon vapors at high concentrations during surface intervals, consumption of spilled oil through respiration or ingestion, and direct oiling. Dispersants could reduce these incidents and provide an opportunity for animals to move to relative safety.

For the above reasons, the Sanctuary recommended a change in policy on dispersant use near the Flower Gardens. The recommended policy allows dispersant us under appropriate conditions (as determined by the Federal On-Scene Coordinator), and encourages application in water as deep as possible and as far from the Sanctuary as possible, in order to promote dilution of dispersed oil and minimize effects on shallow-water organisms. It also requests consultation as well as immediate notification of any decision to apply dispersants so that it may consider timely implementation of appropriate monitoring and assessment protocols.

REVIEW OF INDUSTRY PLANS

MMS requests review by NOAA of exploration and development plans, as well as pipeline proposals, submitted by companies operating in the "Four-Mile Zone" around the Flower Gardens. Sanctuary staff reviews and comments primarily on aspects that could affect Sanctuary resources, including discharge shunting requirements, proposed platform and barge anchor patterns relative to existing pipelines and Sanctuary boundaries, pipeline routes and safety settings, spill response plans, and spill notification procedures. Through this process, companies are also notified of existing regulations that might affect their operations, and as appropriate, the current status of policy revisions, such as those affecting dispersant use or spill notification.

PLATFORM REMOVAL

The Flower Gardens Sanctuary includes the entire No-Activity Zone of each bank, rounded out to enable easy identification of the Sanctuary for enforcement purposes (Fig. 2). Within the Sanctuary is one gas production platform. The facility has been producing since 1982, but is reaching the end of its economic life.

Removal of a production platform generally involves plugging of wells, removal of the upper section, explosive severing of the supporting legs below the mudline, and removal of the jacket by crane to a barge. On-going studies in the Gulf are showing that explosive removal frequently causes high mortality of fish within the community that has developed around the structure (Gitschlag pers comm). Because the platform in the Sanctuary is within 500 m of the East Flower Garden Bank, it is possible that fish over natural hard-bottom habitats may also be affected by the removal (by the effects of explosives and possibly by habitat destruction caused by barge anchoring).

For these reasons, NOAA is consulting with the operator, MMS, and the Texas Parks and Wildlife Department, which administers the Texas Artificial Reef Program, in an effort to minimize impacts to Sanctuary resources. Removal options being discussed include various explosive and non-explosive (so-called "mechanical" cutting) techniques. Mechanical severance below the mudline, for example, would reduce the fish kill caused by explosives. It would, however, also remove habitat that the fish it protects may depend on. Therefore, also under consideration is the option of leaving a large portion of the structure in place as a permanent artificial reef. This would not only minimize the impact to living resources, but also would provide for future natural resource production in the Sanctuary.

DISCUSSION

The Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA), which established the National Marine Sanctuary Program, required that marine sanctuaries "...be of a size that will permit comprehensive and coordinated conservation and management." The determination of sanctuary boundaries around the Flower Gardens reflected the judgement that effective resource protection could be accomplished by adopting roughly the same area protected by the MMS "No-Activity Zones" (the Sanctuary area is 143.21 km^2) That is, the Sanctuary needed to be no larger to effectively protect the banks from identified, legitimate threats to their health, and ensure long-term preservation.

That MPRSA also requires "[facilitation], to the extent possible with the primary objective of resource protection, [of] all public and private uses of the resources of these marine areas not prohibited pursuant to other authorities." This "multiple use" concept requires that commercial activities be allowed as long as they are not detrimental in a significant way to sanctuary resources. At the Flower Gardens, aside from the use of gear that harms benthic habitats, commercial fishing is not impeded. Furthermore, because of the effectiveness of stipulations promulgated by MMS in 1974, Sanctuary regulations have done little to affect normal activities associated with oil and gas production. Recreational diving operations are actually facilitated by Sanctuary operations, which provide for mooring buoy maintenance and education programs. This creates the balance, envisioned in the MPRSA, between conservation and economic development.

Continuing this balance will require constant vigilance, communication, cooperation with other resource management agencies and resource users, education, research, monitoring, and enforcement. In the context of this paper, research and monitoring are particularly important to mention. Virtually all the Flower Gardens Sanctuary regulations, boundary determinations, inter-agency agreements, policy decisions, and policy changes have been justified on the basis of previous or on-going objective scientific research. Because of this, management decisions have rarely been questioned by commercial or regulatory interests.

Objectivity requires up-to-date information that can only be provided by monitoring and research. The monitoring program at the Flower Gardens is considered a high priority project by both MMS and NOAA. Current research efforts, funded by the Sanctuary, the oil industry, state agencies, the recreational dive community, and other outside sponsors are providing information crucial to resource management: reef fish community dynamics (including Osteichthyes and elasmobranchs); coral reproduction and recruitment; sea turtle populations; the prevalence, etiology, and dynamics of coral diseases; the development of reef coral restoration techniques; artificial reef community dynamics; and historical climate change and its relationship to reef condition. Research is needed on water quality and its dynamics; oceanic processes affecting the reefs; fish recruitment processes; toxicology as it relates to vessel discharges, spills, and spill countermeasures; and human dimensions of resource use, particularly user levels and economic valuation.

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